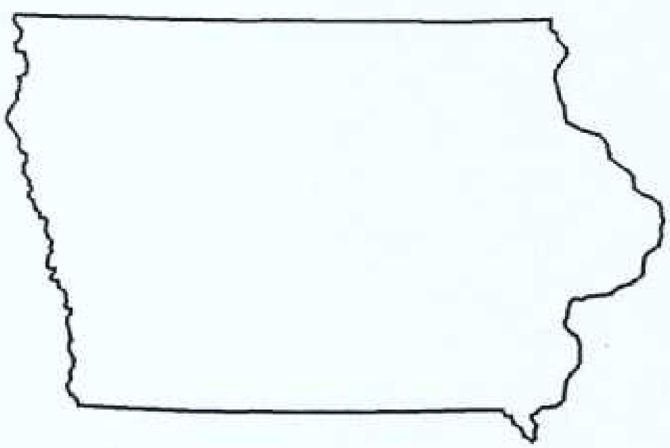
U.S. Fish and Wildlife Service
Region 3
Contaminants Program

1992 Contaminant Survey of the Upper Mississippi River National Wildlife and Fish Refuge, Pools 12 and 14

Study ID #: 3103

by Tracy A. Copeland



U.S. Fish and Wildlife Service
4469 - 48th Avenue Court
Rock Island, Illinois 61201

May 31, 1995

ABSTRACT

Sediments and tissue samples from five areas in and near the Upper Mississippi River National Wildlife and Fish Refuge were analyzed for inorganic and organic contaminants in 1992. Tissue residue analysis did not indicate uptake of contaminants to levels which may cause acute adverse effects to trust resources. Two areas, Wise Lake and Swan Slough, were determined to have elevated concentrations of contaminants in sediments. Inorganic contaminants in Wise Lake are most likely naturally occurring, and may not be available to wildlife. Sediment contamination in Swan Slough is most likely anthropogenic. Two polycyclic aromatic hydrocarbons detected in this slough may be present in concentrations which may be harmful to benthic organisms, under currently proposed US EPA criteria.

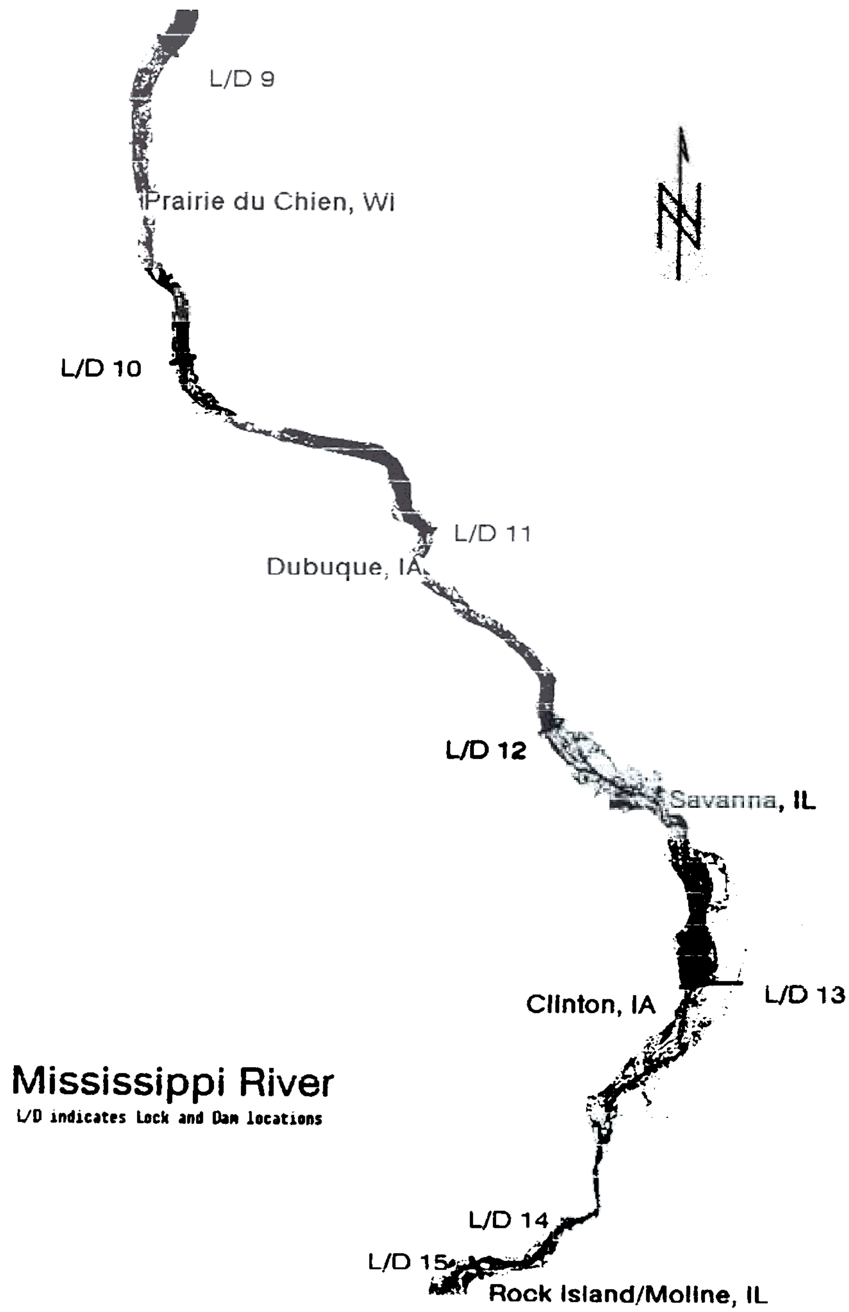


Figure 1. Map of the Upper Mississippi River, Pools 10 through 15.

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ACKNOWLEDGEMENTS

Mike Coffey, Terri Jacobson, Heidi Woeber, Linda Miller, and Debbie Dee offered a great deal of sampling assistance during this study. The Savanna District kept their eyes open, and turned in several wildlife mortalities for analysis. Jody Millar gave great editorial and sampling assistance. Jody Millar, Terri Jacobson, Larry Wargowsky, and Linda Miller also offered review comments on the draft report. Sharon Gilliam shared her expertise in table creation, word processing questions and final report layout. Thank you to everyone for their assistance.

INTRODUCTION

The Upper Mississippi River National Wildlife and Fish Refuge (UMRNWFR) contains approximately 195,000 acres of Federal land, administered by the U.S. Fish and Wildlife Service (Service). It is the longest national wildlife refuge in the lower 48 states, spanning 260 miles of the Upper Mississippi River from Wabasha, Minnesota to Rock Island, Illinois. The area of this study included portions of the refuge from Pool 10 (Harpers Ferry, Iowa) to Pool 14 (LeClaire, Iowa). This is a distance of approximately 165 river miles.

Backwaters, sloughs and side channels of the refuge provide protected habitat for sport fish, large river fish, nesting and migrating neotropical birds and waterfowl. The refuge and the river basin provide extensive habitat to breeding and wintering bald eagles and other significant birds of prey. Sloughs and bottomlands support myriads of breeding heron and egret colonies; while many side channels nourish populations of State and Federally listed endangered mussels. Backwater areas are also havens for many waterfowl and furbearing species, which are critical to the hunting and trapping industries.

In 1985 the Rock Island Field Office, together with the Twin Cities Field Office, conducted a preliminary contaminant assessment of the refuge. Samples were collected from Wabasha, Minnesota (river mile 758.6) to Princeton, Iowa (river mile 504). A total of 83 sites were sampled for sediment and/or tissue analysis. Laboratory analysis of the samples revealed that, with the exception of a few sites, the refuge was generally within or below accepted background concentrations of hazardous contaminants.

In the 1985 study, fifteen sampling sites, from Pool 10 through Pool 14, tested above the levels presented by Long and Morgan as effects range-low in their 1991 publication. An effects range-low determination was defined by the lower 10 percentile of chemical concentrations observed or predicted to be associated with biological effects. The median of these concentrations was defined as the effects range-median (Long and Morgan, 1991). These values are not presented as sediment quality criteria, but rather show a general trend among sediment samples taken nationwide.

Five of the fifteen 1985 sites had results exceeding the effects range-median levels. Of these five, one site was not directly linked with the river (the Dubuque Detention Basin) and was not included in this study and two sites (Wise Lake, and Wise Lake Island) were treated as one. Swan Slough and Beaver Slough were included and sampled in more detail.

The refuge manager for the Savanna District had expressed concern about the possible impacts from two industrial sites in Pool 12. The Menominee River barge terminal area and the chemical terminal near river mile 573 were scheduled for sampling because of these concerns.

This 1992 study was initiated to further define the contaminant problem areas discovered during the 1985 study and those areas of concern to the refuge, through more directed sampling.

Table 1. 1992 Sample Sites, with 1985 Sediment Contaminant Concentrations and Comparison Values (ppm dry weight), Upper Mississippi River National Wildlife and Fish Refuge.

	Cr	Pb	Ni	Zn	Phenanthrene	Fluorene	PCB
Methodist Lake*	23	22	22	85.3	not detected	not detected	not detected
Wise Lake	38	110	26	697	not detected	not detected	not detected
Wise Lake Island	31	81	25	525	not detected	not detected	not detected
Beaver Slough	19	280	11	95.7	3.0	0.25	0.19
Swan Slough	231	20	20	453	484	117	not detected
Effects Range - Median	145	110	50	270	1380	640	400 (ppb)

* Methodist Lake was used as a control site for the resuspended sediment toxicity tests

Goals and Objectives

1) Define the extent of the problems within previously identified contaminated reaches; 2) examine food chain uptake through tissue residue analysis and 3) determine if current management objectives need to be modified to account for contamination present in specified locations.

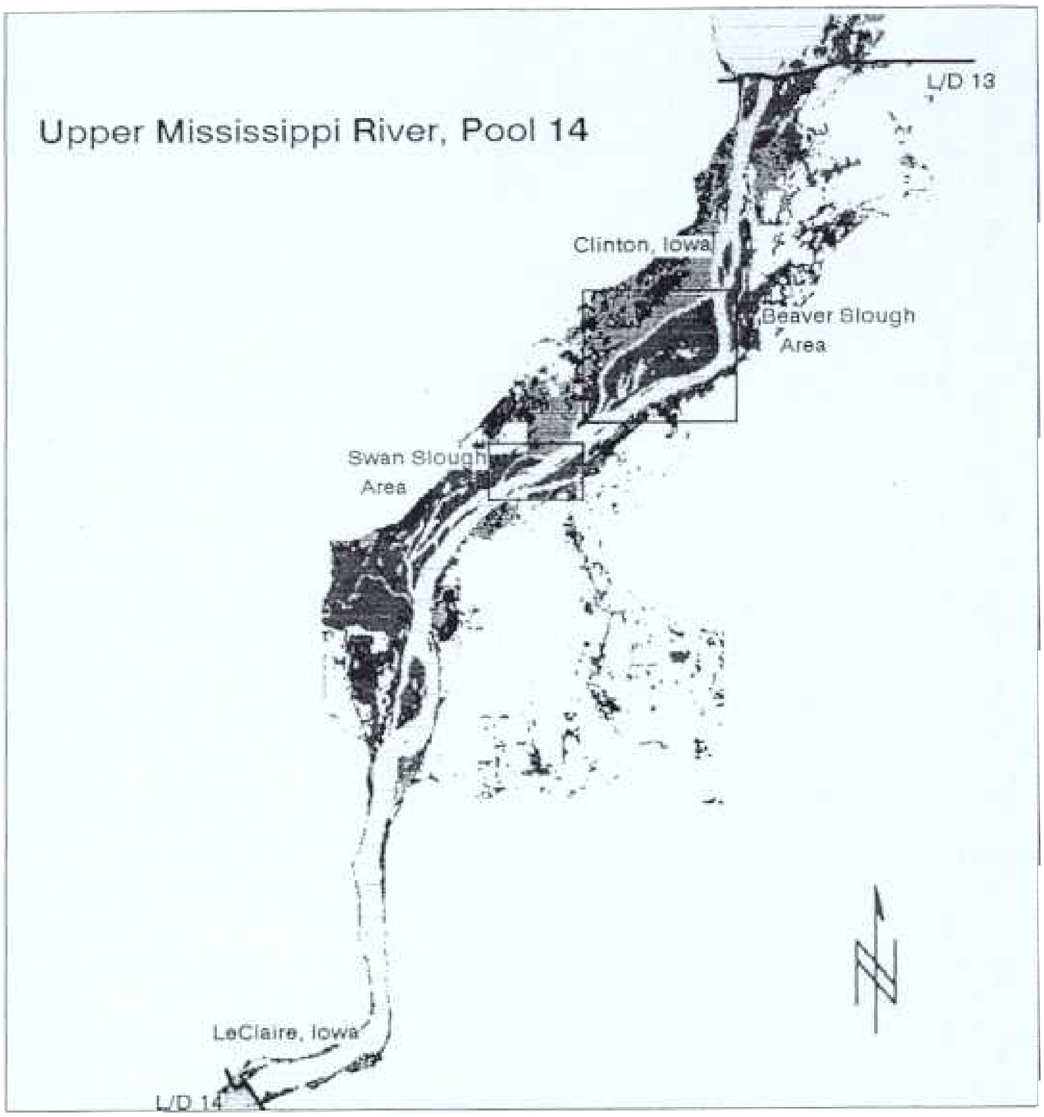
SITE DESCRIPTIONS

Figure 2 illustrates the locations of the Pool 14 sampling sites

Swan Slough

Swan Slough is located between river miles 510 and 511.2, in Pool 14, south of the town of Camanche, Iowa (Figure 3). The slough has one sewage treatment plant discharge and one industrial discharge point from a chemical manufacturing plant. Until 1992-1993, there had been two industrial discharges. However, the Arcadian Corporation has extended their

Figure 2. Pool 14, Upper Mississippi River, Showing the 1992 Sampling Locations.



Land Cover/Use
1989

- Open Water
- Aquatic Vegetation
- Grass/Forbs
- Woody Terrestrials
- Agriculture
- Urban/Developed
- Sand
- Cloud Cover

Scale: 0 — 5 — 10 mi

Source: 1:100,000 USGS Digital Line Graphs (DLG)
from NBS-EMTC (Onalaska, WI)
Projection: UTM - Zone 15; NAD 27
Polygon Cell Size: 5 x 5 meters
Produced by Tracy A. Copeland
USFWS Rock Island Field Office
May 25, 1995

discharge pipe out to the main channel to achieve greater mixing. There is one public boat launching area at approximately river mile 510.75. Sediments in the slough range from some silt to a high percentage of sand. Historically, sediments contaminated with weathered polycyclic aromatic hydrocarbons (PAHs) have been found in the slough, close to the remaining industrial discharge. Fish flesh has been identified as tainted from this slough (U.S. Environmental Protection Agency, 1977). The 1985 study, conducted by the Service, detected several organic contaminants in sandy sediments from this location. Swan Island, located along the southeastern boundary of the slough, is managed for wildlife by the UMRNWFR.

Beaver Slough

This industrialized slough is located in Pool 14, between Camanche, and Clinton, Iowa (Figure 4). The Slough has one tributary creek and provides a border for the refuge's Beaver Island complex. Beaver Island supports a heron colony during nesting season. In 1992, the island also was struck by fall out from an explosion at the Archer Daniels Midland plant located on the Slough.

Industrial effluent to this slough includes discharges from grain processing plants, chemical companies, and power companies. This slough receives a fast flow from the main river, and the substrate is mostly sand. Elevated concentrations of metals and organic contaminants were detected here in 1985.

Pool 12 sites are illustrated in Figure 5.

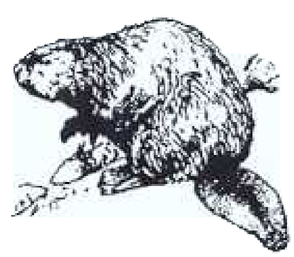
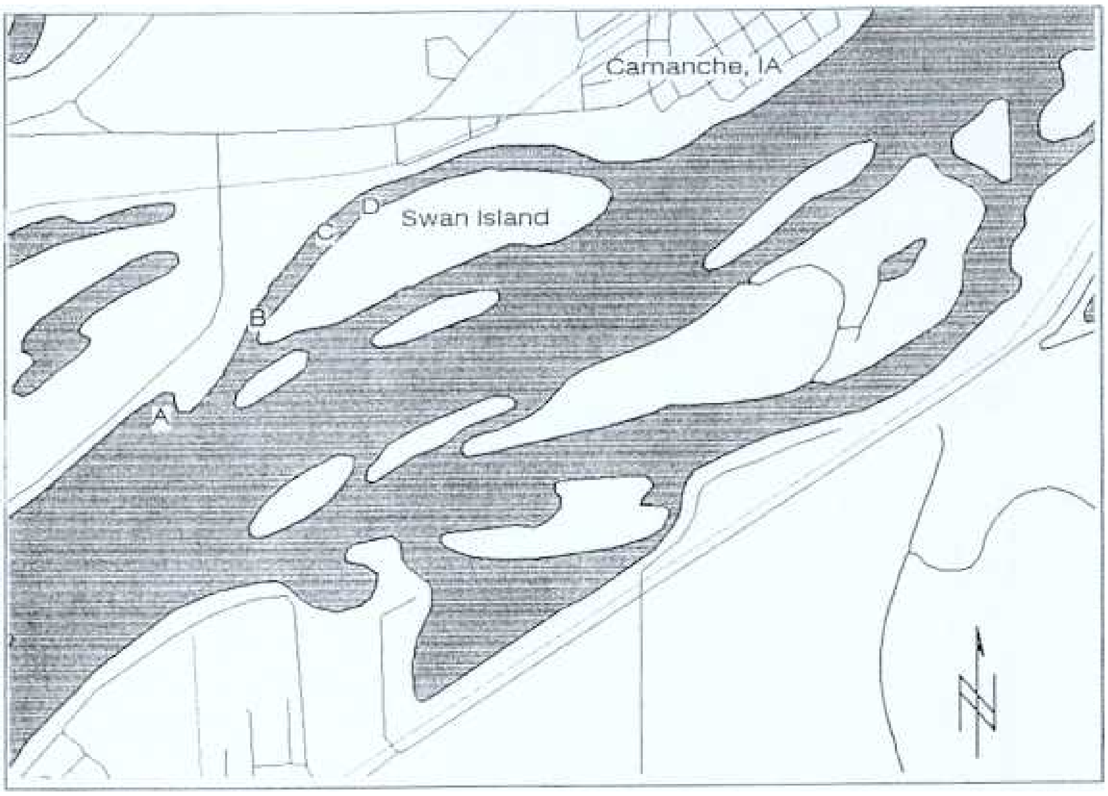


Figure 3. 1992 Sampling Sites in Swan Slough (SS), Pool 14, Upper Mississippi River.



Scale: 0 0.50 1 mi

Letters correspond to sample sites from the 1992 field study.

Color Key

Land

Water

Tributaries

Railroads

Roads

Source: 1:100,000 USGS Digital Line Graphs (DLG) from NBS-EMTC (Onalaska, WI)
Projection: UTM - Zone 15; NAD 27
Polygon Cell Size: 5 x 5 meters
Produced by Tracy A. Copeland
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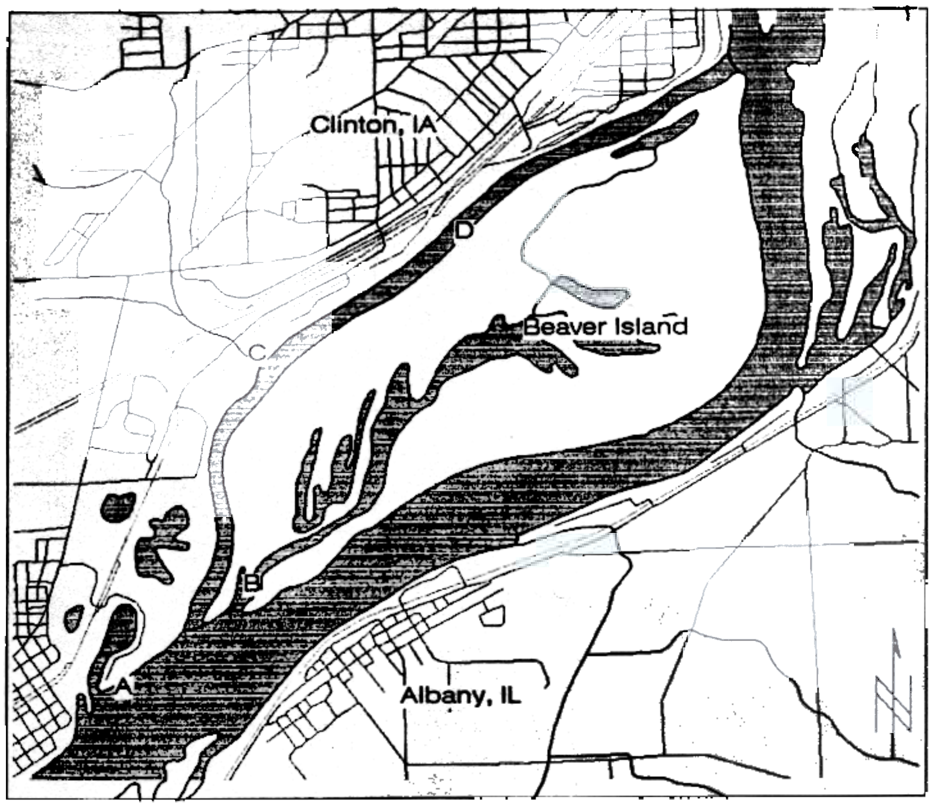
April 24, 1995

Figure 4. 1992 Sampling Sites in Beaver Slough (BS), Pool 14, Upper Mississippi River.



Scale: 0 1 2 mi

Letters correspond to sample sites from the 1992 field study.

Color Key

Tributaries

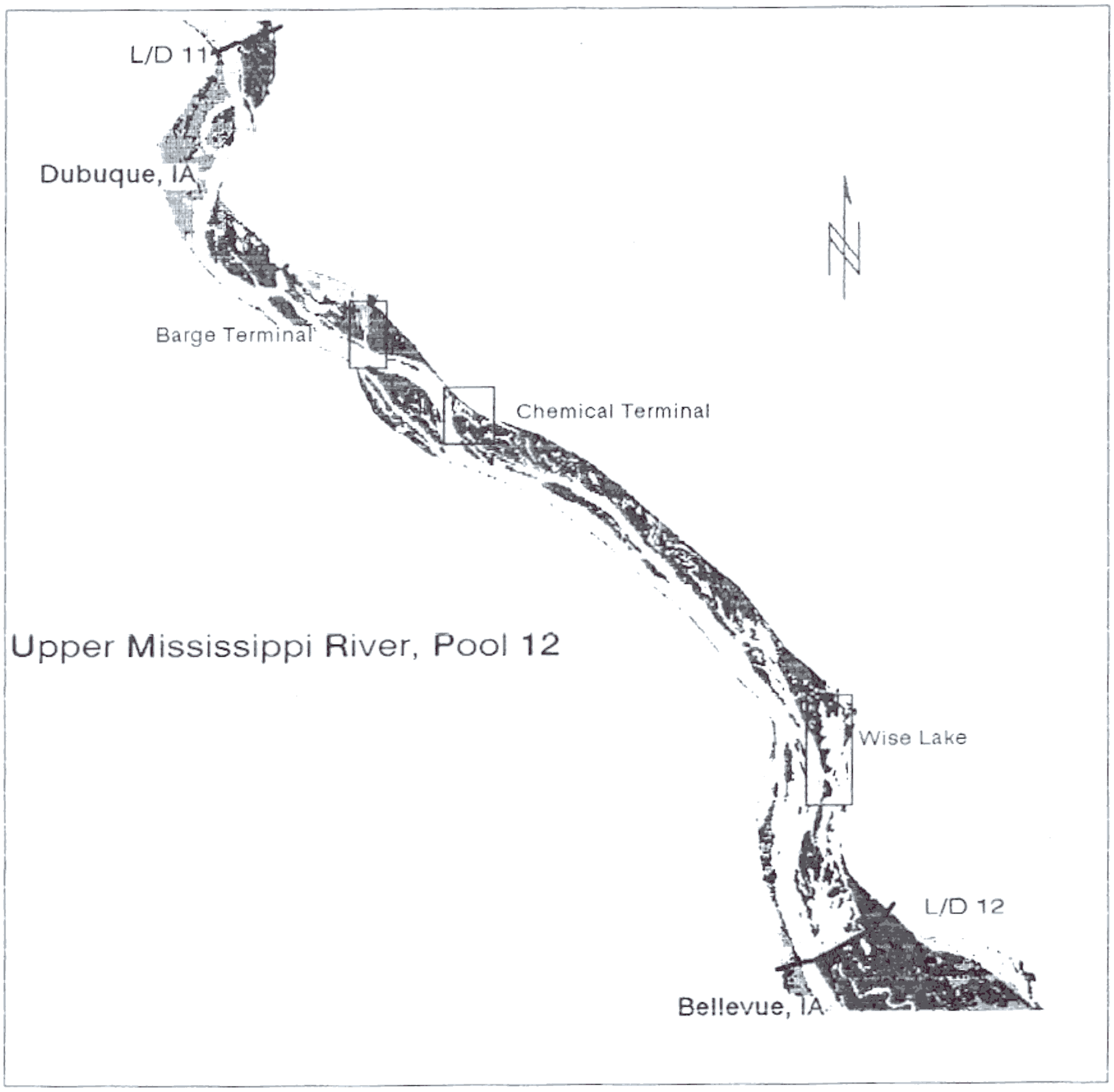
Railroads

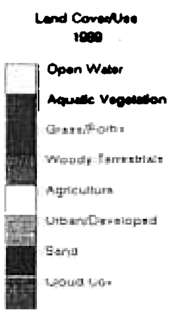
Water

Roads

Source: 1:100,000 USGS Digital Line Graphs (DLG) from NBS-EMTC (Onalaska, WI)
Projection: UTM - Zone 15; NAD 27
Polygon Cell Size: 5 x 5 meters
Produced by Tracy A. Copeland
USFWS Rock Island Field Office
April 24, 1995

Figure 5. Pool 12, Upper Mississippi River, Showing the 1992 Sampling Locations.





Scale: 0 5 10 mi

Source: 1:100,000 USGS Digital Line Graphs (DLG)
from NBS-EMTC (Onalaska, WI)
Projection: UTM - Zone 15; NAD 27
Polygon Cell Size: 5 x 5 meters
Produced by Tracy A. Copeland
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May 25, 1995

Wise Lake

Wise Lake is a backwater lake in Pool 12, between river miles 560 and 562.5 (Figure 6). It is located in the historic lead mining area of Illinois, in close proximity to the town of Galena. The lake has a number of residential homes built around it, as well as the boat dock for the Chestnut Mountain Resort. There is a railroad line running along the Illinois shoreline of this lake. The lake is a popular fishing spot and offers habitat to migrating wildlife. Large populations of diving ducks are monitored on this lake annually. During the 1985 sampling, elevated concentrations of lead and zinc were detected in the sediments of this lake.

Chemical Terminal

Located in East Dubuque, Illinois, there are industrial docks at river mile 573 (Figure 7), in Pool 12. The company manufactures and loads agricultural chemicals. The submerged discharge pipe for this facility is also located at this river mile. The chemical company handles a great deal of ammonia which can be very toxic to fish and wildlife.

Menominee River Barge Terminal

This terminal is located adjacent to the refuge at river mile 575.5, in Illinois (Figure 8). The potential exists for contaminants to be released from the facility during fueling and unloading operations. A heron rookery was located near this site, but has been abandoned for several years, since the construction of the terminal.

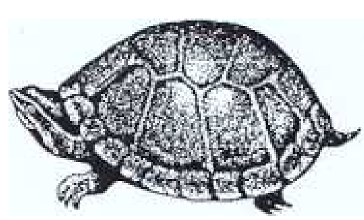
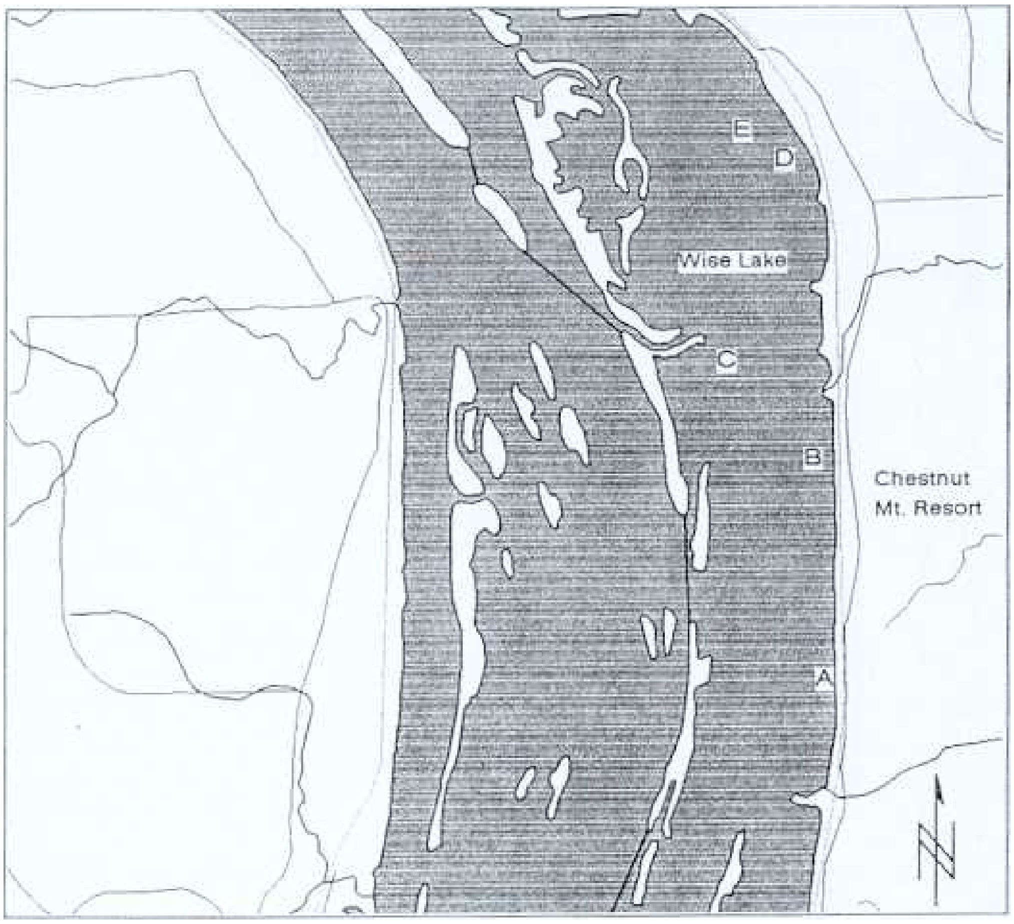


Figure 6. 1992 Sampling Sites in Wise Lake (WL), Pool 12, Upper Mississippi River.



Scale: 0 — 1 — 2 mi

Letters correspond to sample sites from the 1992 field study.

Color Key

Land

Water

Tributaries

Railroads

Roads

Source: 1:100,000 USGS Digital Line Graphs (DLG) from NBS-EMTC (Onalaska, WI)
Projection: UTM - Zone 15; NAD 27
Polygon Cell Size: 5 x 5 meters
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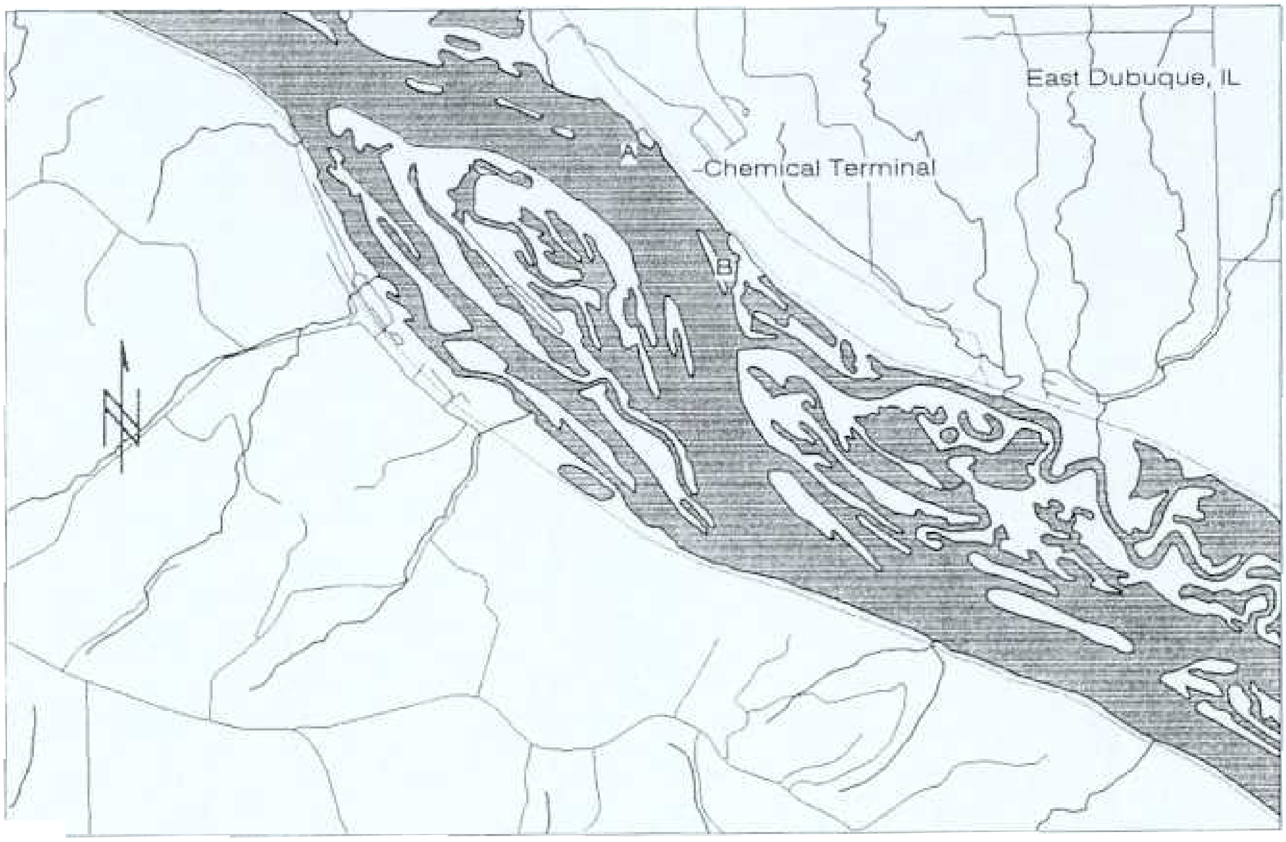
Figure 7. 1992 Sampling Sites near the Chemical Terminal (PC), Pool 12, Upper Mississippi River.



Scale: 0 1 2 mi

Letters correspond to sample sites from the 1992 field study.

Source: 1:100,000 USGS Digital Line Graphs (DLG) from NBS-EMTC (Onalaska, WI)
Projection: UTM - Zone 15; NAD 27
Polygon Cell Size: 5 x 5 meters
Produced by Tracy A. Copeland
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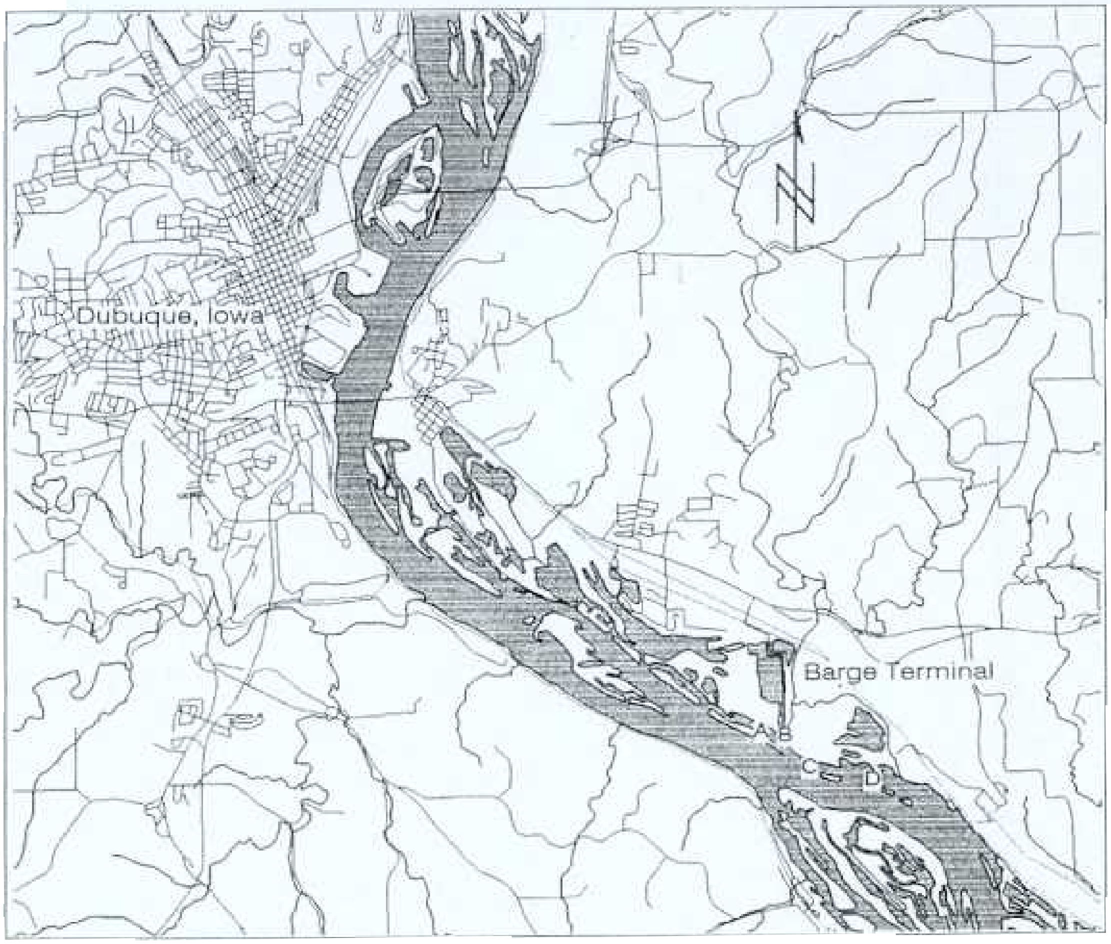
April 25, 1995

Color Key
Land
Water

Tributaries
Railroads
Roads

Figure 8. 1992 Sampling Sites near the Menominee River Barge Terminal (BT), Pool 12, Upper Mississippi River.



Scale: 0 2.50 5 mi

Letters correspond to sample sites from the 1992 field study.

(no samples analyzed at B)

Color Key

Land

Water

Tributaries

Railroads

Roads

Source: 1:100,000 USGS Digital Line Graphs (DLG)
from NBS-EMTC (Onalaska, WI)
Projection: UTM - Zone 15; NAD 27
Polygon Cell Size: 5 x 5 meters
Produced by Tracy A. Copeland
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April 25, 1995

METHODS

Sediment sampling

All of the samples were collected using a petite ponar dredge. The dredge was dropped over the side of an anchored aluminum jon boat, using a twenty-five foot length of rope. Sampling depth varied from three feet to ten feet.

Once the dredge had been tripped by impact with the river bottom, it was brought back into the boat and the contents placed into a stainless steel pan. Sample containers were filled using a long handled stainless steel spoon. All of the stainless steel utensils and pans were rinsed with site water and acetone between samplings. The acetone rinse was allowed to air dry between samples.

If the sediment was to be analyzed for inorganic elements, the sample was spooned into a sterile whirl-pak bag.

Samples which were collected for organic analysis were placed in one quart chemically clean glass jars, leaving approximately 1.5 inches of air space at the top of the jar to allow for freezer expansion, and sealed with a teflon coated lid.

All of the collected samples were stored on blue ice in the field, and placed in a standard chest freezer upon return to the field office. Samples were stored frozen for a minimum of five months prior to receiving authorization to ship to the contract laboratory. Samples were shipped on dry ice.

Tissue sampling

<u>Mussel collections</u>

Mussels were collected at two sites for this study. They were collected in Beaver Slough and in Swan Slough. Both of these locations are in Pool 14.

Collections were made with a 12-foot brail bar. The bar consisted of a 12-foot long piece of weighted,lumber, which had numerous chains on which five or more crow-foot hooks were attached. The bar was then lowered into the river and dragged over the substrate very slowly. As the hooks drag lightly and slowly over the substrate, the mussels become irritated. They open their shells and clamp onto the hooks. After a distance of approximately 20 yards had been covered, the brail bar was lifted back onto the boat. Any mussels collected were removed and placed into a pail of site water.

The mussels were then identified and measured. Tissue samples were taken from the individuals of the same species. Samples were taken from species only when there was the potential of yielding a workable sample weight. Specifically, species which were submitted for analysis were the three ridge (*Amblema plicata*) and the pocketbook (*Lampsilis ovata ventricosa*) mussels.

Once a sufficient sample size was collected (usually three to five individuals), the mussels were pried open using a knife. A composite of tissue from at least three individuals was scraped into a chemically clean glass jar with a mussel hook. Both the knife and mussel hook were cleaned between samples using site water and a hexane rinse. The hexane was allowed to air dry before the instrument was used. The sample was labelled and placed on blue ice until it could be frozen at the field station.

Avian tissue samples

During the course of the study several double-crested cormorant nestlings, at a colony in Pool 13, were blown out of their nests during a severe wind storm. Three moribund specimens were collected.

These birds were euthanized, wrapped in aluminum foil and put into a clear plastic bag. The plastic bag was placed in a cooler with blue ice. Upon reaching the field office the carcasses were transferred to a standard chest freezer. They were subsequently transferred to the Madison Wildlife Health Research Center for necropsy. Once it was determined that there was no pathological cause of death, the carcasses were wrapped in plastic and returned to the field office in a standard cooler, on blue ice.

At the field office the liver and kidney was removed from each specimen, using chemically clean dissecting tools. The dissecting blades, probes and tweezers were washed using hospital grade detergent and placed in a 10% solution of chlorine bleach until used. The biologist performing the dissections was dressed in a standard cotton lab coat, face mask and goggles, and used sterile gloves. The tissues were composited by organ type, placed in separate glass jars, labelled and refrozen. Upon receipt of the authorization to ship, the tissues were submitted, on dry ice, to the contract laboratory and analyzed for metals.

Three dead mallards were collected from Pool 12 by persons at the Frentress Lake Marina. These birds were stored in plastic garbage bags in a standard freezer before transfer to the field office. Transfer to the field office was accomplished using blue ice and a cooler. At the field office the birds were transferred to a chest freezer prior to shipment to the Madison Wildlife Health Research Center. These specimens were diagnosed as having botulism C, which was most likely the cause of death.

Dissections of these mallards followed the protocol established during the cormorant dissections. The contract laboratory was advised of the health diagnosis when the samples were submitted for metals analysis.

A juvenile great blue heron was retrieved, from Pool 13, by personnel from the Savanna District. The liver and kidney from this bird were submitted for analysis, using the techniques described above.

Chemical analysis

Chemical analysis was performed by Texas A & M's Geochemical & Environmental Research Group (GERG). All analyses were conducted under the Patuxent Analytical Control Facility (now Patuxent Environmental Research Center) Standard Operating Procedures. Laboratory results were reviewed and approved by the PACF Quality Assurance/Quality Control Officer prior to release.

Detection limits used by the contract laboratory, for organic compounds, varied between samples. Detection limits used for inorganic samples varied between compounds, but remained constant between samples. In each case, the detection limit was sufficiently low to document elevated concentrations of any chemical as compared to Long and Morgan, US EPA, and the Ontario (Canada) Ministry of the Environment trends or guidelines.

Resuspended sediment (Rototox) toxicity testing

Toxicity testing was performed to determine whether or not these contaminated sediments, when resuspended through turbulence, become available to fish and wildlife resources. Such turbulence may be caused by barge traffic, pleasure boats, or under natural conditions such as spring time high water, wave fetch or major flooding.

The LaCrosse, Wisconsin field office of the Columbia National Fisheries Research Center (now the Midwest Science Center) conducted this aspect of the study under contract with the Rock Island Field Office. Composite sediment samples were collected by Science Center biologists at sites identified by the field office. Sediments were analyzed for contaminant concentrations, in addition to being placed in a rototox chamber with juvenile fish. One copy of the report "Bioavailability of Trace Metals to Green Sunfish (*Lepomis cyanellus*) Exposed to Suspended Sediments from Sites on the Upper Mississippi River" has been submitted to the Region 3 Regional Office under separate cover.

RESULTS

Data results have been tabulated for easy reference. These tables are presented in Appendix A (inorganics) and Appendix B (organics).

Sediments

Swan Slough

Arsenic was detected in all eight samples from this slough. Concentrations ranged from a low of 1.1 ppm to a high of 8.1 ppm. Concentrations of inorganic compounds detected in sediments are presented in Table 6 (Appendix A).

Cadmium was detected in six out of the eight inorganic samples from Swan Slough. The lowest concentration was present upstream of the sewage treatment plant (0.2 ppm), while the highest concentration of 2.86 ppm was found immediately downstream of the industrial outfall.

Chromium was present at every sampling location in the slough, and ranged from 9.8 ppm to 1053 ppm. Swan Slough had the highest concentration of chromium detected from all the samples submitted for analysis.

The highest concentration of nickel detected in Swan Slough was 39.9 ppm. Lead ranged from 6.5 to 30.2 ppm, while zinc concentrations ranged from 21.8 ppm to 2007 ppm. Swan Slough was also the only location where mercury was detected. Concentrations at the two positive sites were 0.141 and 0.167 ppm.

Twenty one polycyclic aromatic hydrocarbons (PAHs), including oil and grease, were detected at one or all of the eight sites sampled. Swan Slough consistently had the highest concentrations of PAHs in sediments. Minimum total PAH concentrations in this area, including oil and grease, ranged from 122.708 to 1225.894 ppm (Table 2). The slough also had the highest detected concentrations of 1,6,7-trimethyl-naphthalene (9.450 ppm), oil and grease (1189.464 ppm), acenaphthene (2.309 ppm), anthracene (1.654 ppm), fluoranthene (1.647 ppm) and phenanthrene (7.203 ppm).

Total polychlorinated biphenyls (PCBs) in Swan Slough ranged from 0.014 ppm to 0.086 ppm. Individual arochlors detected in the slough included PCB 126 (0.017 ppm), PCB 128 (0.017 ppm), PCB 156/171/202 (0.0172 ppm). PCB 1254 concentrations ranged from 0.011 ppm to 0.0171 ppm and was detected in seven out of eight samples from this location.

Table 2. Highest Calculated Total PAHs in Sediments, Pools 12 and 14, Upper Mississippi River National Wildlife and Fish Refuge, 1992 (ppm dry weight).

	Min. TOTAL PAH	Min. TOTAL PAH (less oil/grease)
SS-B1	1225.894	36.430
BS-C2	529.148	0.449
BS-D2	123.143	0.825
PC-A3	240.309	0.707
BT-A2	375.841	0.146
BT-A4	189.872	0.433

SS = Swan Slough; BS = Beaver Slough; PC = Chemical Terminal; BT = Barge Terminal

Beaver Slough

Arsenic concentrations, ranging from 1.1 to 6.2 ppm, were detected in all eight sediment samples from this slough. Cadmium, however, was only detected in two samples. Concentrations were 0.26 and 0.27 ppm.

Chromium and nickel were also detected in every sediment sample from Beaver Slough. Concentrations of chromium ranged from 4.2 ppm to 18.9, while nickel was present at 5.6 to 19.8 ppm.

Mercury was not detected in any sediment sample submitted from this slough. Concentrations of lead ranged from 7.6 ppm to 13.1 ppm in six of eight samples. Zinc concentrations were 5.3 ppm to 73 ppm, with one sample having no detectable zinc.

Nineteen PAHs were detected in one or more sediment samples from Beaver Slough. Minimum total PAH concentrations in this area, including oil and grease ranged from 71.422 ppm to 529.148 ppm (Table 2). Maximum concentrations were 0.071 ppm 1,6,7-trimethyl-naphthalene, 528.699 ppm oil and grease, 0.014 ppm anthracene, 0.094 ppm fluoranthene, and 0.088 ppm phenanthrene. Acenaphthene was not detected in Beaver Slough.

Total PCBs were detected in only two samples from this industrialized slough. Concentrations detected were 0.0138 ppm and 0.0743 ppm. Individual arochlors were detected in sediments from one sample location: PCB 118/108/149 (0.0185 ppm), PCB 138 (0.0185 ppm), PCB 180 (0.0185 ppm), PCB 66 (0.0185 ppm), and PCB 1254 (0.0673 ppm).

Wise Lake

All fourteen sediment samples from this backwater lake contained detectable concentrations of arsenic. Concentrations of this metalloid ranged from 3.7 ppm to 7.8 ppm. With concentrations ranging from 0.27 to 2.26 ppm, cadmium was detected in all but five samples from Wise Lake.

Chromium was detected in every sediment sample at this location. Concentrations of this metal range from 12.8 to 26.66 ppm. Mercury was not detected in this backwater.

Nickel, lead and zinc were detected in every sample from Wise Lake. Concentration ranges were 13.5 to 30.9 ppm nickel; 6.9 ppm to 30.2 ppm lead; and 46.9 to 1209 ppm zinc.

Organic contaminants were not perceived to be a problem, based on the 1985 study, and were not analyzed in Wise Lake sediments during this study.

Chemical Terminal

Arsenic concentrations ranged from 2.6 ppm to 6 ppm. The metalloid was detected in all four submitted samples. Cadmium was found in three out of the four sediment samples submitted. Concentrations ranged from 0.21 ppm to 0.94 ppm.

Chromium ranged from 7.6 ppm to 12.9 ppm, while mercury was not detected in any sample from this location.

Nickel was detected at concentrations between 8.9 ppm and 16.8 ppm. Lead concentrations were between 8.3 ppm and 66 ppm, while zinc was found at 31.9 to 555 ppm.

Fifteen PAHs were detected in one or more sediment samples from this area. Maximum calculated total PAHs were 240.309 ppm, maximum oil and grease concentrations were 239.602 ppm. Anthracene was detected in two of four samples. The highest concentrations of this compound was 0.0.016 ppm. Fluoranthene, detected in three of four samples, had a maximum concentration of 0.095 ppm, and the maximum concentration of phenanthrene, detected in two of four samples, was 0.057 ppm. 1,6,7-trimethyl-naphthalene and acenaphthene were not detected in any samples submitted from this location.

Polychlorinated biphenyls were not detected in any samples from the area of the loading docks around the chemical terminal.

Menominee River Barge Terminal

Arsenic was also detected in all six inorganic sediment samples from this location. Concentrations ranged from 1.7 to 2.8 ppm. Cadmium was detected in only two samples from this location. Concentrations of this metal in the two samples were 0.21 ad 0.22 ppm.

Chromium concentrations ranged from 6.5 to 12 ppm and was detected in every sample. Mercury was not detected in any sample from this location.

Nickel, lead, and zinc were also detected in every sample. Concentrations ranged from 7 ppm to 10.8 ppm nickel; 6.9 to 10.3 ppm lead; and 25.8 to 41.3 ppm zinc.

Fourteen PAH compounds were detected in the vicinity of this barge terminal. Maximum total PAH concentrations were 189.872 ppm. 1,6,7-trimethyl-naphthalene was detected in one of seven samples at a concentration of 0.012 ppm. Maximum oil and grease concentrations detected were 375.695 ppm. Acenaphthene and anthracene were not detected in any samples from this area, while fluoranthene, detected in six of the seven samples had a maximum concentration of 0.033 ppm. Phenanthrene was detected in two-thirds of the samples from the area surrounding the barge terminal. The maximum concentration of this compound was 0.026 ppm.

PCBs were detected in two samples. Total PCB concentrations were 0.0149 ppm and 0.099 ppm. Arochlors PCB 66 and PCB 87 were detected in one sample. The concentrations detected were the same at 0.0165 ppm. PCB 1254 was detected in both positive samples. The concentrations were 0.0144 and 0.089 ppm.

Tissues

Mussels

Arsenic, cadmium and zinc were detected in the tissues of every composite mussel sample submitted for analysis. The range of concentrations, in wet weight, were: 0.462 ppm to 0.629 ppm (arsenic), 0.032 ppm to 0.059 ppm (cadmium), and 20.03 ppm to 46.55 ppm (zinc).

Chromium and lead were detected in the mussels collected from Swan Slough only. Concentrations of chromium were 0.61 and 0.98 ppm (wet weight); while lead concentrations were 0.096 ppm and 0.147 ppm (wet weight).

Mercury was detected in one mussel sample from Beaver Slough. A concentrations of 0.0173 ppm (wet weight) was recorded. A Beaver Slough mussel sample also yielded the only positive reading for nickel, at 0.970 ppm (wet weight).

Eight classes of PAHs were detected in the mussel samples submitted from Pool 12. Of these eight classes, only C-1 naphthalenes were not detected in the mussels from Swan Slough. Wet weight concentrations of the other classes ranged from a low of 0.0076 ppm of C-3 phenanthrenes and anthracenes to a maximum of 0.0087 ppm of C-1 fluoranthenes and pyrenes.

There was only one class of PAHs detected in the mussels submitted from Beaver Slough. One sample detected 0.0086 ppm (wet weight) of C-1 naphthalenes. All other PAH compounds were below the detection limits for mussel tissue submitted from this slough.

Tissue samples were not submitted for PCB analysis

Cormorants

Arsenic, mercury and zinc were detected in the composited kidneys and livers of three pre-fledge cormorants from Pool 13. Wet weight results for arsenic are 0.227 ppm (kidney) and 0.345 ppm (liver). Mercury was detected at 0.178 ppm (kidney) and 0.366 ppm (liver), and zinc wet weight results were 26.28 ppm (kidney) and 64.065 ppm (liver). Cadmium, chromium, nickel and lead were not detected in either organ composite.

No organic analysis was performed on these samples.

Mallards

Neither chromium nor nickel were detected in the liver or kidney of two mallards submitted from Pool 12. Arsenic was detected in the kidney (0.207 ppm wet weight) and liver (0.190 ppm wet weight) of one mallard. Cadmium was detected in both organs, in both birds. Maximum concentrations (wet weight) were 4.167 ppm (kidney) and 0.554 ppm (liver).

Wet weight mercury concentrations were 0.046 ppm (kidney) and 0.44 ppm (liver). Lead and zinc were also detected in both organs of both birds. The maximum lead detected was 0.721 ppm (wet weight kidney) and 0.515 ppm (wet weight liver). Zinc concentrations had a maximum detection of 26.91 ppm (wet weight kidney) and 47.99 ppm (wet weight liver).

No organic analyses were conducted on these samples.

Juvenile great blue heron

Arsenic, cadmium, chromium, and lead were not detected in either the liver or the kidney of this specimen. Mercury was detected in both the kidney (0.209 ppm wet weight) and liver (0.395 ppm wet weight). Nickel was detected in the kidney only. A concentration of 0.238 ppm (wet weight) was recorded. As with mercury, zinc was detected in both the kidney (19.433 ppm wet weight) and liver (59.645 ppm wet weight) of this juvenile great blue heron.

No polycyclic aromatic hydrocarbons were detected in the body of this bird

DISCUSSION

Metals

Metals are naturally occurring elements which may be expected to be present at concentrations similar to those found in the Earth's crust in any given sample. However, the biggest issue is whether or not metals which are detected are also bioavailable. The bioavailability of metals, and their toxicity, are dependent on the physical and chemical form of the metal, the organism affected, and the chemical characteristics of the surrounding environment. There is no one analytical method which will accurately determine the metals that are bioavailable and toxic (U.S. EPA, 1992).

Many metals are required to support biological functions, and therefore, the presence of a metal concentration in a tissue sample is not always indicative of a toxic problem. It is only when concentrations exceed normal ranges, or when a metal binds in an abnormal manner, to inhibit natural functions, that problems may occur.

Table 3. A Comparison of Effects Levels, with Maximum Concentrations, for Selected Metals and Metalloids in Sediments (ppm dry weight), Upper Mississippi River National Wildlife and Fish Refuge, 1992.

	Long and Morgan (1991)			Swan Slough		Wise Lake (WL)	
	ER-L[a]	ER-M[b]	AET[c,d]	B1	B2	B2	B3
Arsenic	33	85	57	6.8	8.1	7.8	6.08
Cadmium	5	9	5	1.66	2.86	1.3	ND
Chromium	80	145	260	721	1053	26.6	17.63
Lead	35	110	450	23	30.2	107.1	76.3
Mercury	0.15	1.3	2.1	0.141	0.167	ND	ND
Nickel	30	50	>140	30.2	39.9	30.9	16.9
Zinc	120	270	410	410	1424	2007	1209

a Effects Range - Low
b Effects Range - Median
c Apparent Effects Threshold
d 1988 Puget Sound - benthic

Arsenic

Arsenic is a naturally occurring metalloid, that is present in rock, soil water, and living organisms. In tissue, arsenic is constantly being metabolized, while compounds in soils are continuously being dissolved. Elevated levels of arsenic may be found with pyrite deposits, or as the result of man made influences such as glass or textile industries or the manufacture and use of different pesticides (Eisler 1988a).

Several sediment samples had concentrations of arsenic which exceed the moderately polluted level of 3 ppm dry weight established by the US EPA for sediments in the Great Lakes. Those concentrations which were detected in Wise Lake are most probably related to the high ore content of this geographic location. The Swan and Beaver Slough concentrations are most likely anthropogenic in origin, when one reviews the number of industrial outfalls present in these areas.

Of the many forms and compounds of arsenic, elemental arsenic is the least toxic to biota (Eisler 1988a). The metals scan was calibrated to report on elemental arsenic rather than its varied compounds. This does not indicate that no arsenic compounds were present, but that the atomic absorption digestion process used during sample preparation would have reduced these compounds to elemental arsenic and other chemicals.

Concentrations of arsenic exceeded the EPA's Great Lakes criteria for heavily polluted sediments (> 8.0 ppm) in one sample from Swan Slough. Sediments exceeded the Ontario Ministry of the Environment lowest effect level of 6.0 ppm (Jaagumagi 1992) in both Swan Slough and Wise Lake sediments, with one sample each from Beaver Slough and the chemical terminal meeting or slightly exceeding this point. However, concentrations of this element were well below the apparent effects threshold determined by Long and Morgan in 1991.

In avian species and freshwater biota, background concentrations of arsenic are usually found at <1.0 mg/kg (ppm) wet weight. These concentrations may be significantly higher in areas near mining operations or certain industrial production (Eisler 1988a). No tissues analyzed during this study exceeded this reference value.

Cadmium

Cadmium is relatively rare, in nature, and there has been no evidence to suggest that it is essential to life. This metal has been proven to be a carcinogen and a teratogen. Freshwater biota appear to be the most sensitive organisms, with concentrations of less that 10 ppb cadmium proving lethal to insects, crustaceans, and teleost fish (Eisler 1985).

Sediments from Swan Slough, Wise Lake, and one sample from the chemical terminal exceeded the lowest effect level of 0.6 ppm. No samples exceeded the effect range-low or apparent effects threshold of 5 ppm.

Responses of the zebra mussel (*Dreissena polymorpha*) to cadmium indicate that at water concentrations of only 9 ppb the filtration rate of the mussel may be significantly affected during a 10 week exposure test (Kraak, et. al. 1992). The higher the concentration of cadmium the mussels were exposed to, the more inhibited the filtration rate became, with total disruption of the filtration rate at 399 ppb cadmium. Also, cadmium was found in mussel tissue at every concentrations tested during the Kraak study.

Cadmium has been observed to significantly decrease the respiration of the pocketbook mussel, *Lampsilis ventricosa* (Naimo et. al. 1992). Concentrations of 111 ppb and 305 ppb also appear to lower the ammonia excretion rate of this species, but this test indicated that the decrease in excretion was not significant when compared to control specimens. Exposure to cadmium in the Naimo experiment did not appear to affect the tissue condition index (tissue mass to shell mass) of the test organisms.

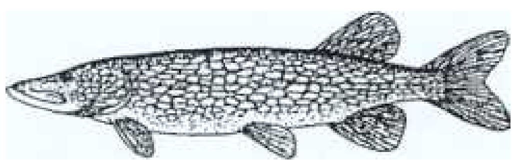
In another study, background cadmium concentrations, detected in mussels from the Illinois River, ranged from 0.2 - 1.4 ppm wet weight, while concentrations of 2.3 ppm (wet weight) and 7.4 ppm (wet weight) were detected in the kidney of a lesser scaup and ring-necked pheasant, respectively (Eisler 1985). Cadmium concentrations detected, in both mussel and avian tissues, during this study were within these background concentrations.

Chromium

This metal is widely used in the production of stainless steel, chrome plating, and the manufacture of pigments and other chemicals (Eisler 1986). Historically, chromium has also been used in the tanning industry. Some of the chemical forms of this metal are toxic to fish and wildlife, primarily the tri and hexavalent forms. Chromium is an essential element in mammals, maintaining several metabolic processes, such as glucose and protein metabolism (Eisler 1986).

Background concentrations of chromium in freshwater sediments can range from 1 ppm to more than 25,000 ppm, depending upon the proximity of chromium producing industries (Eisler 1986). The US

EPA considers sediments containing more than 25 ppm as moderately polluted in the Great Lakes (US EPA 1977); while Long and Morgan (1992) determined that 260 ppm was the apparent effects threshold during their status and trends survey.



Several sediment samples collected in Swan Slough and Wise Lake exceeded EPA's moderately polluted criteria of 25 ppm. Only sediments from Swan Slough exceeded the apparent effects threshold of 260 ppm.

Avian tissue background concentrations have been reported as 0.02 ppm (wet weight) in canvasback liver. Molluscan background concentrations (in snails) have been reported as 450 ppm (dry weight) (Eisler 1986).

Chromium concentrations were detected in two of the 1992 mussel tissue samples from Swan Slough. The concentrations did not exceed the background concentration reported for snails.

Lead

The deleterious effects of lead have been well documented, both in human populations and in wildlife. Many studies have been conducted concerning the effects of lead shot on migratory waterfowl Such documented evidence has led to the banning, in the United States, of lead shot for waterfowl hunting. There is also a current effort to limit or ban the use of lead fishing sinkers.

Although acute exposure to lead has lessened over the years, there is concern over continuous exposure to low levels of this metal (Eisler 1988b). Exposure to lead has historically come from lead based paints, industrial waste from batteries, lead mining operations, lead additives to gasoline, spent lead shot and lead fishing sinkers.

Lead is toxic to all aquatic biota, but effects may be modified when considering different variables (Eisler 1988b). In many animals, symptoms of lead toxicosis may include emaciation, and lethargy. Chemical analysis would indicate elevated blood and tissue levels.

Eisler reports that sample sediment concentrations of lead may range from 1 ppm in Chesapeake Bay to 11,000 ppm in Norway. Sediments sampled in the Upper Mississippi River ranged from 0.4 - 86 ppm.

Only sediments from Wise Lake exceeded the lowest effect level of 31 ppm. No sediment samples exceeded concentrations of 110 ppm, the effects range - moderate established by Long and Morgan.

Reported tissue analysis has revealed background concentrations of lead as follows: 5 ppm in Chesapeake Bay bivalves, 0.1 (fresh weight) in Missouri green backed heron liver samples, and 6 - 45 ppm (dry weight) in mallard wing bones.

Avian tissue residues, in 1992, were slightly above the documentation for Missouri green backed herons, but this may be a species related variation. Lead concentrations were detected in mussels from Swan Slough, however, they are below the concentrations cited for Chesapeake Bay bivalves.

Mercury

Elemental mercury has no known metabolic function, and its presence in biological tissue may be potentially hazardous. Mercury has been mined for over 2000 years and has been used in such industry as paper, plastics, gold mining, the manufacture of electrical instruments and in pharmaceuticals and agricultural chemicals (Eisler 1987). Organic mercury compounds, such as methyl mercury, have been found to be more toxic to biota than elemental mercury; and elemental mercury is converted to these more toxic forms through natural processes.

In uncontaminated areas, mercury concentrations in sediments may range from 0.02 to 0.11 ppm in north central United States. Contaminated sediments may have concentrations ranging from 0.1 ppm to 746 ppm. Freshwater mollusks have been documented with mercury concentrations of 0.05 ppm to 2.1 ppm (fresh weight); while liver tissue from wood ducks have had reported concentrations of 0.1 ppm fresh weight in juveniles and 0.2 ppm in adults (Eisler 1987).

Evidence presented in the literature has suggested that total mercury concentrations of 0.1 to 2.0 ppb in tissues may be lethal to sensitive aquatic organisms. This range may vary among species, and between fresh and saltwater systems.

1992 sediment samples did not indicate the presence of mercury, except at Swan Slough. The concentrations detected in the two positive samples were above the effects range - low, but below the effects range - median established by Long and Morgan.

Every tissue sample, except one three ridge mussel sample, was positive for mercury. Only the composited livers of the cormorants and both tissue samples from the great blue heron exceeded the concentrations discussed above. This may be a species related variation. The fact that these specimens were euthanized, with no other determinable cause of death found, seems to indicate that the mercury concentrations were not acutely toxic in these select birds.

Nickel

Nickel is commonly found in nature together with cobalt. It is relatively unreactive in a chemical sense. Historically, nickel has been used in industry to coat other metals which may oxidize. It is also used in the production of stainless steel and other alloys (Pilar 1979).

Nickel contamination in the environment can come from diverse sources. These may include mining, the use of fossil fuels and wastewater treatment facilities, as well as the above referenced sources. Mallard ducklings showed adverse reactions when fed concentrations of 1200 ppm nickel sulphate. Ducklings which were fed 200 and 800 ppm, in the same experiment did not show the same reactions. Physical effects included partial paralysis, tremors, less weight gain and a 71% mortality rate (Cain and Pafford 1981).

Three of the 1992 sites exceeded the lowest effects level of 16 ppm. These were Swan Slough, Beaver Slough and Wise Lake. Of these, two sites in Swan Slough and one site in Wise Lake exceed the effects range-low value of 30 ppm. Trace amounts of nickel (dry weight) were detected in the kidney of the great blue heron, and in one mussel sample from Beaver Slough.

Zinc

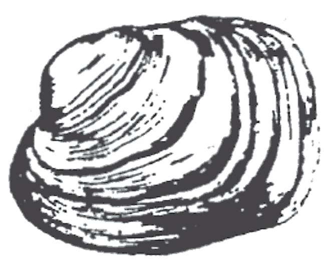
Zinc is a naturally occurring trace element necessary for metabolism, particularly on certain enzymes that regulate RNA and DNA. However, zinc toxicosis has been documented in both wildlife and human populations. Toxicosis in animals most likely occurs through the ingestion of galvanized metals, paints, and agricultural fertilizers (Eisler 1993).

Zinc is used primarily in producing alloys, brass, and galvanizing metals. It is also used in fungicides, as a soil additive and can be used to minimize toxic effects of other metals, such as copper and arsenic.

Reported concentrations of zinc in sediments range from 50 - 138 ppm (dry weight) in Canadian streams and rivers to 12 - 20 ppm in sediments sampled in the northeast United States. Tissue concentrations of 41.4 ppm (fresh weight) have been reported in the livers of blue winged teal and 649 ppm (dry weight) in black crowned night herons from North Carolina (Eisler 1993).

Eight sediment samples exceed the established severe effects level of 820 ppm. Two of these samples were immediately downstream of the industrial outfall in Swan Slough, and six samples were from Wise Lake.

Tissue sample concentrations of zinc ranged around the previously presented value for blue winged teal. No tissues exceeded the black crowned night heron concentration. Variations of zinc concentrations between species is great. Within a species, variation may occur depending upon age, size, season and other conditions. Some species may be able to regulate and store excess zinc.



Organics

Organic compounds are compounds which contain carbon. For the purposes of this study, only two groups of organic compounds were studied: polycyclic aromatic hydrocarbons (PAHs), and poly-chlorinated biphenyls (PCBs).

Table 4. A Comparison of Effects Levels with Maximum Concentrations for Selected Organic Compounds in Sediments (ppm dry weight), Upper Mississippi River National Wildlife and Fish Refuge, 1992.

	Long and Morgan (1991)[1]			Swan Slough	
	ER-L	ER-M	AET	B1	B2
Acenaphthene	0.150	0.650	0.730	2.309	1.585
Anthracene	0.085	0.960	4.400	1.654	0.754
Chrysene	0.400	2.800	9.200	0.518	0.138
Fluoranthene	0.600	3.600	24.00	1.647	0.5
Fluorene	0.035	0.640	1.000	4.324	2.569
Naphthalene	0.340	2.100	2.700	0.189	0.669
Phenanthrene	0.225	1.380	–	7.203	4.463
Pyrene	0.350	2.200	16.00	3.217	0.968
Total PAH	4.000	35.00	–	36.43[2]	14.85[2]

[1] converted from ppb to ppm

[2] minimum calculated PAH less oil and grease

Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs are compounds composed of carbon, in benzene rings, and hydrogen. They may be by-products of such industry as: iron and steel manufacture, heating and power generation and petroleum refining. PAHs may also be introduced into the environment through natural causes such as fire, and microbial processes.

Higher molecular weight PAHs, which may contain four to seven benzene rings, are less acutely toxic than the lower weight compounds, however, they have been proven to be significantly more carcinogenic, mutagenic, and teratogenic to aquatic life, amphibians, birds and mammals. These compounds are rapidly metabolized and tend not to biomagnify through the food chain (Eisler, 1987).

In response to section 304(a)(1) of the Clean Water Act, as amended, the US EPA has proposed criteria for three PAHs for the protection of benthic organisms. US EPA draft documents on phenanthrene, anthracene, and fluoranthene were made available for comment in January, 1994. Final rulings are anticipated in 1995.

The draft criteria is the agency's best recommendation on the concentrations of these three compounds. These recommended concentrations do not take into account additive, synergistic or antagonistic effects or bioaccumulative effects to aquatic biota (US EPA 1993).

PAHs were present in sediment samples from every site. However, the highest concentrations were detected in Swan Slough. Twenty one different PAHs were found within the sampling reach in Swan Slough. Two of these sites exceeded the criteria proposed by the EPA for phenanthrene and acenaphthene.

In order to determine a site specific criteria for the Upper Mississippi River, it was necessary to multiply the proposed criteria by the percent total organic content (Table 9, Appendix B) at each sampling location (USFWS 1994). Site specific criteria for phenanthrene was calculated to be 1.962 ppm and 1.116 ppm (Table 5). Results from these two sampling locations were 7.204 ppm and 4.464 ppm respectively. Both of these sites are immediately downstream of an industrial discharge.

Table 5. Swan Slough Site Specific Criteria for Phenanthrene, Acenaphthene, and Fluorene in Pool 14, Upper Mississippi River, 1992 ($\mu g/g$ dry weight)

Site Number	Phenanthrene	Acenaphthene	Fluorene
SS-B1	1.962	1.417	6.758
SS-B2	1.116	0.806	3.844

At these same locations the site specific criteria for acenaphthene were calculated to be 1.417 ppm and 0.806 ppm. The concentrations of the hydrocarbon in the sediments were 2.309 and 1.586 ppm.

Background concentrations of total PAHs have been detected from 104 to 13,900 ppb in sediments of Cayuga Lake, New York, and 87,000 to 120,000 ppb in the Charles River, Massachusetts. Total PAHs in organic tissue have been reported as ranging from 3-8 ppb (fresh weight) in Lake Ontario fish muscle (Eisler 1987).

Minimum total PAHs were calculated by adding the detectable concen trations reported. These values ranged from 42.06 ppm near the chemical terminal to 1225.89 ppm in Swan Slough.

Six classes of PAHs were detected in mussels from Swan Slough, while only one class was detected in the 1992 specimens from Beaver Slough. No other tissues were tested for organics. Because of the lack of compound specific data in this study, the results were not compared with specific compound references which may be found in the literature.

Polychlorinated biphenyls

PCBs are man-made halogenated aromatic hydrocarbons. Historically, PCBs have been found in lubricants, dielectric agents, plasticizers, and heat transfer agents. From the early 1970s they were used as insulating agents in closed electrical systems, like transformers (Eisler 1986). These compounds are very persistent, and have been documented in the sediments of the Upper Mississippi River in several locations.

Polychlorinated biphenyls have migrated into the environment through varied sources. Atmospheric transport, leaks from wastewater treatment systems, and dump sites are just a few of the sources of this contamination. In 1979 the US EPA implemented a ban on the manufacture and processing of PCB compounds, unless specifically exempted. Because of the persistence of these compounds, they may still present significant hazards to wildlife resources (Eisler 1986).

Acute toxicity values for aquatic organisms may vary, depending upon the specific PCB compound and length of the exposure period. Birds appear to be more resistant to acute toxicity than mammals. However, signs of PCB toxicosis in birds may include tremors, deviations in beak structure and incoordination. Sublethal effects of these compounds may include skin lesions, immuno and reproductive toxicity and epigenetic effects (Eisler 1986).

In one PCB study on the Mississippi River, the highest concentrations of PCBs in *Hexagenia* mayflies were found in pools near Minneapolis/St. Paul, MN and Iowa/Illinois Quad Cities metropolitan areas. The sample results from the Pool 2 sites (Minneapolis area) indicate that the source is most likely the Metro Wastewater Treatment Plant. The results of the Pool 15 sites indicate a point source somewhere in the Quad Cities. This site is most likely a disposal lagoon for industrial waste oil along the Iowa shore (Steingraeber et. al. 1994).

PCBs were detected in some sediment samples from thee of the five 1992 study sites. Positive results were detected in Swan Slough, Beaver Slough and near the Menominee River Barge Terminal. All of these areas have some type of industry located in close proximity which may have generated PCBs historically. The concentrations detected were very low, never exceeding 0.1 ppm dry weight.

Acid Volatile Sulfide

The bioavailability of metals in sediments is related to the chemical environment and activity of the specific metal in the interstitial pore water. In recent experiments the toxicity to benthic organisms has been influenced by sulfide and metal concentrations. This sulfide fraction is referred to as the acid volatile sulfide (AVS). No significant mortality has been observed when the concentration of AVS in sediments is greater than the concentration of simultaneously extracted metals from the same sediments (Di Toro et. al. 1992).

The acid volatile sulfide values obtained during this study were not simultaneously extracted with the metal samples, and the extended holding time most likely makes these values inaccurate (Di Toro et. al. 1990). The results of the AVS analysis are included in Table 6 (Appendix A) as a point of interest only. Should future studies be conducted on the sediments of the Upper Mississippi River, acid volatile sulfide should be examined in greater detail, at that time.

CONCLUSIONS

Based upon previous river studies conducted by the Fish and Wildlife Service, metal concentrations in the sediments of the Mississippi River and backwaters sampled during this study, continue to appear elevated. In Wise Lake, where concentrations of zinc and lead were above recent sediment criteria, this most likely is a result of naturally occurring geological formations. The Wise Lake area is part of the historic Galena, Illinois lead mining district.

Other locations with elevated metals are most likely caused by anthropogenic activities. These areas include Swan Slough, which had elevated concentrations of zinc and chromium. Anthropogenic activities may impact areas through point source or non-point source discharges. The bioavailability of the metals, detected in this study, was not determined due to the method of analysis.

Concentrations of metals which were detected in the collected tissue samples were not indicative of acute toxicity. Because of the young age of the majority of these samples, and the method of analysis, chronic toxicity was not addressed.

In the sites where biotic samples were collected, metal contamination does not appear to offer an acute and immediate threat to fish and wildlife resources. Future histopathological studies of sick or dead animals from these sites may yield more information concerning chronic effects of metals.

Aromatic hydrocarbons were most prevalent at the two study areas in Pool 14. Swan Slough had concentrations of phenanthrene and acenaphthene exceeding those drafted by the US EPA for the protection of benthic organisms.

During 1993, the Upper Mississippi River was subjected to major flooding, which resulted in high water, increased flow and scouring of backwater channels and sloughs. During a return visit to Swan Slough in November 1993, no PAH contaminated sediments were visually apparent. It is unknown if these contaminated sediments have been scoured out of the slough or merely covered over by new deposits of sand. Further sediment sampling and coring would be required to determine this.

RECOMMENDATIONS

1. Continue with current management plans.

2. The field office will submit the data from Swan Slough to the US EPA, Kansas City, Missouri. The field office will also continue monitoring sediments in this slough to determine if the problem is of an historic nature, or of a continuing nature.

3. If contaminated sediments are detected visually at the industrial discharge site in Swan Slough, the contaminants biologist will work

the Iowa Department of Natural Resources and the US EPA to clean up the area and/or adjust the National Pollution Discharge Elimination System (NPDES) permit requirements.

4. Determine the bioavailability of the metals during future projects.

5. All refuge and ecological service field personnel will submit dead or moribund wildlife found at Wise Lake or Swan Slough immediately to the National Wildlife Health Center for histopathological examination. Histopathology may be more indicative of certain metal toxicoses than basic residue analysis. Copies of the laboratory diagnoses will be sent to the Rock Island Field Office contaminants biologist for record keeping.

6. Test for acid volatile sulfide with *simultaneously* extracted metals, during future inorganic sediment sampling.

7. If concern for metal and hydrocarbon contamination persists, conduct *in situ* bioassays, especially at Swan Slough and Wise Lake. The toxicity tests will assist in the determination of acute or chronic effects to benthic species from elevated concentrations of these contaminants.

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Appendix

Results Inorganic Residue Analyses

Table 6. Sediment Concentrations of Inorganic Compounds, Upper Mississippi River National Wildlife and Fish Refuge, 1992 (ppm dry weight).

	% Moisture	AVS	Al	As	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Se	Zn
SS-A1	33.8	64.1	4945	2.1	.23	14.7	10	12268	ND	332	11.4	9.4	ND	52.7
SS-A2	32.9	101	3671	2.3	.23	13	10.8	11923	ND	358	11	11.8	ND	50.7
SS-B1	42.6	1695	7621	6.8	1.66	721	32.8	23481	0.141	729	30.2	23	ND	1424
SS-B4	48.6	2065	7195	8.1	2.86	1053	34.4	25793	0.167	924	39.9	30.2	ND	2007
SS-C2	28.3	13.6	3295	1.5	ND	10	7	9972	ND	190	8.7	7.3	ND	28
SS-C4	24.9	71.2	3168	1.1	ND	9.8	6.2	9776	ND	158	8	6.5	ND	21.8
SS-D1	30.2	30.5	4800	2.9	.2	14	10.5	13035	ND	3.95	11.6	11.3	ND	47.3
SS-D2	33.7	*	4439	2.6	.2	13.6	9.9	14101	ND	3.87	11.9	9.9	ND	46.6
BS-A1	17.7	14.8	1288	1.1	ND	5.9	3.4	5760	ND	84	7.2	ND	ND	5.3
BS-A2	17.9	11.2	950	1.3	ND	4.2	2.7	3995	ND	71	5.6	ND	ND	ND
BS-B1	34.8	61.9	5747	3.1	.26	15.1	9.7	13736	ND	493	12.9	10.2	ND	55.2
BS-B2	38.7	46.7	5262	3.5	.27	13.6	10.9	14630	ND	586	14	12	ND	60.8
BS-C1	37.6	132	7336	5.5	ND	18.9	15.9	16237	ND	410	19.4	11.6	ND	67.9
BS-C2	32.6	64.4	7915	4.9	ND	18.6	16.9	16919	ND	535	19.8	10.6	ND	67.1
BS-D1	33.4	18.6	3113	3.8	ND	8.2	5.2	10246	ND	565	9.5	7.6	ND	42.9
BS-D2	26.3	9.4	8298	6.2	ND	18.2	12.7	17985	ND	801	18.5	13.1	ND	73
WL-A1	34.2	19.4	8356	4.5	.51	21.2	12.4	23145	ND	664	19	31	ND	303.3
WL-A2	33.7	16.4	7287	4.6	.46	19.5	11.8	21048	ND	625	17.7	31.9	ND	265.8
WL-B1	51.7	189	8693	7.2	1.25	20.3	23.5	23623	ND	891	25.4	99.3	ND	1026
WL-B2	45.9	345	12200	7.8	1.3	26.6	26.6	27713	ND	941	30.9	107.1	ND	1108

SS Swan Slough BS = Beaver Slough WL = Wise Lake no data exist ND not detected

Table 6, continued. Sediment Concentrations of Inorganic Compounds, Upper Mississippi River National Wildlife and Fish Refuge, 1992 (ppm dry weight).

	% Moisture	AVS	Al	As	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Se	Zn
WL-C1	46.4	32.2	4274	3.7	ND	12.8	10.1	11268	ND	477	13.5	18.4	ND	46.9
WL-C2	46	89.7	4377	5.3	1.02	13.8	19.9	17114	ND	782	18.8	68.5	ND	596
WL-D1a	16.76	**	12612	6.68	ND	22.41	19.02	26009	ND	927	22.5	80.8	1	733
WL-D1b	43.03	**	15394	7.25	1.62	24.4	19.83	27200	ND	851	21.8	86	ND	754
WL-D2a	50.25	**	15451	7.22	ND	25.3	21.61	20550	ND	881	26.4	89.1	ND	799
WL-D2b	43.95	**	16738	7.12	.27	26.66	22.18	22574	ND	835	28.8	92.6	ND	819
WL-E1a	35.63	**	9347	5.03	.29	15.8	11.69	15988	ND	680	14.5	64.5	ND	885
WL-E1b	36.2	**	10881	5.85	2.26	19.19	12.75	18213	ND	799	15.6	70.6	ND	986
WL-E3a	35.2	**	11262	6.42	ND	20.09	13.44	18385	ND	807	15.6	71.5	ND	1011
WL-E3b	36.11	**	9645	6.08	ND	17.63	14.84	18556	ND	831	16.9	76.3	ND	1209
PC-A2	42	29.3	3386	3.2	.29	11.6	12.5	12765	ND	607	12.8	12.2	ND	58.3
PC-A4	34.4	18.9	1886	3.2	.21	7.6	8.7	10006	ND	466	9.2	8.3	ND	38.1
PC-B2	28.8	17.1	3992	6	.94	12.9	18.4	16855	ND	740	16.8	66	ND	555
PC-B4	30.9	10.7	2204	2.6	ND	8	7.6	8655	ND	469	8.9	11.2	ND	31.9
BT-A1a	40.2	80.7	2097	2.2	ND	8.4	8.5	9219	ND	529	9.1	8.3	ND	35.7
BT-A3a	42.6	51.1	2672	2.5	.21	10	9.7	11562	ND	627	10.5	8.6	ND	42
BT-C1a	36.5	52.6	3314	2.3	ND	12	8.9	12386	ND	529	10.8	8.8	ND	41.3
BT-C2a	37.4	52.8	2459	2.7	.22	10.1	9.4	10735	ND	540	10.1	10.3	ND	39.5
BT-D1a	28.2	13.6	2615	1.7	ND	8.9	6.1	9235	ND	351	7.6	7.8	ND	26.7
BT-D2a	30.7	53.4	1548	1.8	ND	6.5	5.8	7807	ND	434	7	6.9	ND	25.8

WL = Wise Lake PC = Chemical Terminal BT = Barge Terminal * no data exists ** not analyzed for ND not detected

Table 7.

						7.29	267.52	.66	10	ND	ND	3.17	97.45
COR-Liv	70	ND	1.15	ND	ND	5.57	777.08	1.22	16.79	ND	ND	1.48	213.55
MAL1-Kid	95.8	66.15	ND	9.87	ND	15.49	784.95	*	9.22	ND	2.29	7.5	97.96
MAL1-Liv	68.56	14.45	ND	.84	ND	125.42	4495.12	.14	9.43	ND	1.64	5.24	152.64
MAL2-Kid	72.46	21.82	.75	15.13	ND	20.04	594.87	.17	8.42	ND	2.62	10.55	97.7
MAL2-Liv	65.37	ND	.55	1.6	ND	145.85	3709.7	.11	9.06	ND	1.47	8.35	143.31
GBH-Kid	78.9	23.55	ND	ND	ND	11.1	482	.994	ND	1.13	ND	8.3	92.1
GBH-Liv	74.5	8.0882	ND	ND	ND	27.5	1089	1.548	6.9	ND	ND	6.5	233.9
SS-MUSS1	88.12	893.65	4.33	.27	5.14	9.15	1584.02	ND	1522.93	ND	1.24	2.57	168.58
SS-MUSS2	85.15	212.77	3.11	.4	6.62	5.22	1005.91	*	479.79	ND	.65	2.01	313.5
BS-MUSS1	83.04	119.28	3.71	.34	ND	7.26	602.22	*	1096.46	5.72	ND	3.01	181.26
BS-MUSS2	82.67	527.09	3.44*	.27	ND	6.01	1057.38	.1	844.86	ND	ND	1.95	204.59

* no data exists   ND not detected

Table 8. Avian and Freshwater Mussel Tissue Concentrations of Inorganic Compounds, Upper Mississippi River National Wildlife and Fish Refuge, 1992 (ppm wet weight).

	% Moisture	Al	As	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Se	Zn
COR-Kid	73.03	6.69	0.227	ND	ND	1.962	72.15	0.178	2.697	ND	ND	0.854	26.28
COR-Liv	70	ND	0.245	ND	ND	1.67	233.12	0.366	5.04	ND	ND	0.444	64.065
MAL1-Kid	95.8	2.78	ND	0.415	ND	0.651	32.97	*	0.387	ND	0.096	0.315	4.11
MAL1-Liv	68.56	4.54	ND	0.264	ND	39.4	163.83	0.044	2.965	ND	0.5156	1.647	47.99
MAL2-Kid	72.46	6.01	0.207	4.167	ND	5.519	1413.27	0.0468	2.32	ND	0.7215	2.905	26.91
MAL2-Liv	65.37	ND	0.1904	0.554	ND	50.51	1284.67	0.038	3.137	ND	0.509	2.89	46.63
GBH-Kid	78.9	4.97	ND	ND	ND	2.34	101.70	0.2097	ND	0.238	ND	1.75	19.433
GBH-Liv	74.5	2.06	ND	ND	ND	7.01	277.69	0.395	1.76	ND	ND	1.66	59.645
SS-MUSS1	88.12	106	0.514	0.032	0.61	1.09	188.18	ND	180.92	ND	0.147	0.305	20.03
SS-MUSS2	85.15	31.59	0.462	0.059	0.98	0.775	149.38	*	71.248	ND	0.0965	0.298	46.55
BS-MUSS1	83.04	20.23	0.629	0.058	ND	1.23	102.14	*	185.959	0.970	ND	0.510	30.74
BS-MUSS2	82.67	91.34	0.596	0.047	ND	1.04	183.24	0.0173	146.414	ND	ND	0.3379	35.455

* no data exists　　ND not detected

Appendix B:

Results Organic Residue Analyses

Table 9. Percent Moisture, Percent Total Organic Content (TOC) and Grain Size of Sediments in Pools 12 and 14, Upper Mississippi River National Wildlife and Fish Refuge, 1992.						
	% Moisture	% TOC	% Sand	% Silt	% Clay	% Lipid
SS-A1	42.7	1.15	27.82	59.05	13.13	.1
SS-A2	31.1	.92	28.87	49.23	21.9	.1
SS-B1	42.1	1.09	63.5	14.42	22.08	.7
SS-B2	39.2	.62	NA	NA	NA	.3
SS-B4	NA	NA	31.65	40	28.35	NA
SS-C1	35.3	.54	NA	NA	NA	.1
SS-C2	NA	NA	90.67	3.22	6.11	NA
SS-C3	39.6	.46	NA	NA	NA	.1
SS-C4	NA	NA	72.36	17.02	10.62	NA
SS-D1	25.9	1.48	57.24	32.16	10.6	.2
SS-D2	35.5	.86	NA	NA	NA	.1
BS-A1	22.1	.21	91.15	5.25	3.6	.1
BS-A2	27.7	.06	92.61	4.61	2.8	.1
BS-B1	46.2	.86	49.91	28.69	21.4	.1
BS-B2	33	1.08	28.83	42.67	28.5	.2
BS-C1	52.4	1.16	8.42	55.21	36.37	.1
BS-C2	33.1	1.48	6.53	54.45	39.02	.4
BS-D1	40.4	.75	81.28	9.26	9.46	.1
BS-D2	42.2	.59	61.89	16.65	21.46	.1
WL-A1	NA	NA	30.4	44.1	25.5	NA
WL-A2	NA	NA	41.29	35.73	22.98	NA
WL-B1	NA	NA	4.58	66.06	29.36	NA
WL-B2	NA	NA	7.46	63.07	29.47	NA
WL-C1	NA	NA	1.86	73.44	24.7	NA
WL-C2	NA	NA	1.68	72.21	26.11	NA
PC-A1	41.6	1.14	NA	NA	NA	.1
PC-A2	NA	NA	22.47	63.09	14.44	NA
PC-A3	44.7	1.99	NA	NA	NA	.1
PC-A4	NA	NA	24.68	63.2	12.12	NA

Table 9 (continued). **Percent Moisture, Percent Total Organic Content (TOC) and Grain Size of Sediments in Pools 12 and 14, Upper Mississippi River National Wildlife and Fish Refuge, 1992.**

	% Moisture	% TOC	% Sand	% Silt	% Clay	% Lipid
PC-B1	30.1	1.41	NA	NA	NA	.1
PC-B2	NA	NA	29.99	53.46	16.55	NA
PC-B3	38.5	.98	NA	NA	NA	0
PC-B4	NA	NA	42.79	43.57	13.64	NA
BT-A1	NA	NA	59.79	26.59	13.62	NA
BT-A2	31.7	1.14	NA	NA	NA	.3
BT-A3	NA	NA	56.1	29.85	14.05	NA
BT-A4	39.4	.92	NA	NA	NA	.1
BT-C1	33.3	1.4	53.59	33.03	13.38	.1
BT-C2	46	1.44	47.4	37.79	14.81	.1
BT-D1	27.7	.6	68.35	20.43	11.22	.1
BT-D2	42.9	NA	68.82	19.99	11.19	.1
BT-D3	41.6	.75	NA	NA	NA	.1

NA - not analyzed

Table 10. Polycyclic Aromatic Hydrocarbon (PAH) Concentrations in Sediments, Pools 12 and 14, Upper Mississippi River National Wildlife and Fish Refuge, 1992 (ppm dry weight).

	SS-A1	SS-A2	SS-B1	SS-B2	SS-C1	SS-C3	SS-D1	SS-D2	BS-A1	BS-A2	BS-B1	BS-B2	BS-C1
1,2,5,6 - dibenzanthracene	ND	ND	.015544	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 - benzanthracene	.04363	.034833	.525043	.162829	.034003	.016556	.112011	.049612	.021823	ND	.016729	.023881	.044118
1,6,7 - trimethyl-naphthalene	.031414	.030479	9.450777	.539474	ND	ND	.044534	.029457	ND	ND	ND	ND	.014706
oil/grease *	170.157	166.908	1189.464	492.763	122.256	149.834	221.592	171.472	71.116	142.600	195.167	237.164	505.042
acenaphthalene	.080279	.088534	3.74266	1.960526	ND	ND	.018893	.010853	ND	ND	ND	ND	ND
acenaphthene	.013962	.011611	2.309154	1.585526	ND	ND	.020243	.010853	ND	ND	ND	ND	ND
anthracene	.020942	.018868	1.654577	.754934	ND	ND	.032389	.017054	.012837	ND	ND	ND	.014706
benzo(a)pyrene	.036649	.029028	.236615	.0625	.030912	.011589	.078273	.031008	.021823	ND	.024164	.014925	.014706
benzo(b)fluoranthrene	.031414	.026125	.132988	.04118	.027821	.011589	.071525	.037209	.016688	ND	.016729	.013433	.023109
benzo(e)pyrene	.026178	.021771	.183074	.050987	.021638	.009934	.047233	.021705	.014121	ND	.016729	.01194	.012605
benzo(g,h,i)perylene	.013962	.013062	.141623	.032895	.015456	ND	.024291	.020155	.012837	ND	.01487	ND	.018908
benzo(k)fluoranthene	.031414	.026125	.127807	.039474	.026275	.011589	.068826	.035659	.016688	ND	.016729	.01194	.021008
biphenyl	.013962	.017417	.492228	.185855	ND	ND	.025641	.018605	ND	ND	ND	ND	ND
chrysene	.048866	.040639	.518135	.138158	.030912	.011589	.076923	.048062	.020539	ND	.022305	.016418	.044118
fluoranthene	.080279	.065312	1.647668	.5	.057187	.021523	.167341	.082171	.029525	ND	.013011	.028358	.094538
fluorene	.027923	.026125	4.324698	2.569079	ND	ND	.032389	.018605	.011553	ND	ND	ND	.010504
ideno(1,2,3,-cd)pyrene	.027923	.018868	.115717	.023026	.026275	.009934	.044534	.020155	.016688	ND	.01487	.014925	.014706
naphthalene	.033159	.034833	.189983	.669408	.012365	.009934	.063428	.04031	ND	ND	ND	ND	.016807
perylene	.136126	.119013	.200345	.105263	.094281	.056291	.14305	.139535	.046213	.012448	.137546	.177612	.052521
phenanthrene	.073298	.060958	7.2038	4.463816	.020093	.014901	.133603	.066667	.037227	ND	ND	.014925	.088235
pyrene	.09075	.076923	3.217617	.96875	.055641	.024834	.174089	.082171	.028241	ND	.016729	.028358	.088235

* Results have been truncated to three decimal places. ND = not detected

Table 10 (continued). Polycyclic Aromatic Hydrocarbon (PAH) Concentrations in Sediments, Pools 12 and 14, Upper Mississippi River National Wildlife and Fish Refuge, 1992 (ppm dry weight).

	BS-C2	BS-D1	BS-D2	PC-A1	PC-A3	PC-B1	PC-B3	BT-A2	BT-A4	BT-C1	BT-C2	BT-D1	BT-D2	BT-D3
1,2,5,6 - dibenzanthracene	ND	ND	.012111	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 - benzanthracene	ND	.053691	.091696	.035959	.056058	ND	ND	ND	.042904	.023988	.012963	ND	.015762	ND
1,6,7 - trimethyl-naphthalene	.071749	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	.012448	ND	ND
oil/grease *	528.699	227.181	122.318	201.369	239.602	93.276	41.951	375.695	189.439	99.400	126.111	174.653	122.591	176.712
acenaphthalene	ND	ND	.010381	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
acenaphthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
anthracene	.011958	ND	.013841	.010274	.016275	ND	ND	ND	ND	ND	ND	ND	ND	ND
benzo(a)pyrene	.011958	.038591	.069204	.02226	.030741	ND	ND	ND	.028053	.028486	.011111	ND	.021016	ND
benzo(b)fluoranthrene	.014948	.031879	.057093	.027397	.039783	ND	ND	ND	.031353	.011994	.011111	ND	.010508	ND
benzo(e)pyrene	.022422	.025168	.043253	.018836	.025316	ND	ND	ND	.024752	.038981	ND	ND	.022767	ND
benzo(g,h,i)perylene	.017937	.030201	.053633	.011986	.019892	ND	ND	ND	.013201	.022489	ND	ND	.015762	ND
benzo(k)fluoranthene	.013453	.028523	.051903	.023973	.036166	ND	ND	ND	.033003	.010495	.011111	ND	.010508	ND
biphenyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
chrysene	.046338	.043624	.062284	.027397	.0434	ND	ND	ND	.019802	.037481	.018519	ND	.028021	ND
fluoranthene	.038864	.053691	.093426	.058219	.095841	.010014	ND	.011713	.033003	.014993	.02037	ND	.014011	.010274
fluorene	.010463	ND	ND	ND	.01085	ND	ND	ND	ND	ND	ND	ND	ND	ND
ideno(1,2,3,-cd)pyrene	.014948	.033557	.065744	.02226	.030741	ND	ND	ND	.016502	ND	ND	ND	ND	ND
naphthalene	.014948	ND	.012111	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
perylene	.053812	.030201	.039792	.133562	.16094	.051502	.108943	.111274	.150165	.125937	.15	.06639	.091068	.083904
phenanthrene	.055306	.020134	.044983	.035959	.057866	ND	ND	.010249	.009901	ND	.012963	.028278	ND	ND
pyrene	.050822	.063758	.103806	.053082	.083183	ND	ND	.011713	.031353	.02099	.02037	.012448	.019284	.01027

Results have been truncated to th e decimal places. ND = not detecte

Table 11 Calculated Total PAHs in Sediments, Pools 12 and 14, Upper Mississippi River National Wildlife and Fish Refuge, 1992 (ppm dry weight).

	Min. Total PAH	Min. Total PAH (less oil/grease)
SS-A1	170.8966166	.7396166
SS-A2	167.668524	.760524
SS-B1	1225.894053	36.430053
SS-B2	507.61668	14.85368
SS-C1	122.708859	.452859
SS-C3	150.044263	.210263
SS-D1	222.971216	1.379216
SS-D2	172.251846	.779846
BS-A1	71.422803	.306803
BS-A2	142.612448	.012448
BS-B1	195.477411	.310411
BS-B2	237.520715	.356715
BS-C1	505.617884	.575884
BS-C2	529.148926	.449926
BS-D1	227.634018	.453018
BS-D2	123.143261	.825261
PC-A1	201.850164	.481164
PC-A3	240.309052	.707052
PC-B1	93.337516	.061516
PC-B3	42.059943	.108943
BT-A2	375.841415	.146415
BT-A4	189.872992	.433992
BT-C1	99.735834	.335734
BT-C2	126.379518	.268518
BT-D1	174.770565	.117565
BT-D2	122.839687	.248687
BT-D3	176.816448	.104448

Table 12. PAHs in Freshwater Mussel Tissue, Swan Slough and Beaver Slough, Upper Mississippi River National Wildlife and Fish Refuge, 1992 (ppm dry weight/ppm wet weight).

	SS-MUSS1	SS-MUSS2	BS-MUSS1	BS-MUSS2
% Moisture	89.71	88.04	90.52	89.96
C-1 Fluoranthenes & Pyrenes	.0846/0.0087	ND	ND	ND
C-1 Phenanthrenes & anthracenes	.0726/0.0074	ND	ND	ND
C-1 Naphthalenes	ND	ND	ND	0.0858/0.0086
C-2 Phenanthrenes & anthracenes	0.0809/0.008	0.0824/0.0098	ND	ND
C-3 Phenanthrenes & anthracenes	0.0742/0.0076	0.0733/0.0087	ND	ND
C-3 Fluorenes	ND	0.0589/0.0070	ND	ND
C-3 Naphthalenes	0.0795/0.0081	ND	ND	ND
C-4 Naphthalenes	0.0756/0.0077	0.0684/0.0081	ND	ND

Table 13. Polychlorinated Biphenyl (PCB) Concentrations in Sediments, Pools 12 and 14, Upper Mississippi River National Wildlife and Fish Refuge, 1992 (ppm dry weight).

	SS-A1	SS-A2	SS-B1	SS-B2	SS-C1	SS-C3	SS-D1	SS-D2	BS-A1	BS-A2	BS-B1	BS-B2	BS-C1
PCB 118/108/149	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	.018587	ND	**ND**
PCB 126	ND	ND	.017271	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**
PCB 128	ND	ND	.017271	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 138	ND	ND	ND	ND	ND	ND	ND	**ND**	ND	ND	.018587	ND	ND
PCB 156/171/202	ND	ND	.017271	ND	ND	ND	ND	**ND**	ND	ND	ND	ND	ND
PCB 180	ND	ND	ND	ND	ND	ND	ND		ND	ND	.018587	ND	**ND**
PCB 66	ND	ND	ND	ND	ND	ND	ND		ND	ND	.018587	ND	**ND**
PCB 87	ND	ND	ND	ND	ND	ND	ND	**ND**	ND	ND	ND	ND	**ND**
PCB 1254	.017164	.01101	.071401	.063255	ND				**ND**	ND	.067329	ND	
PCB TOTAL	.017452	.014514	.086356	.065789	ND				**ND**	.013831	.074349	ND	

Table 13 (continued). Polychlorinated Biphenyl (PCB) Concentrations in Sediments, Pools 12 and 14, Upper Mississippi River National Wildlife and Fish Refuge, 1992 (ppm dry weight).

	BS-C2	BS-D1	BS-D2	PC-A1	PC-A3	PC-B1	PC-B3	BT-A2	BT-A4	BT-C1	BT-C2	BT-D1	BT-D2	BT-D3
PCB 118/108/149	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 126	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 128	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 138	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 156/171/202	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 180	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 66	ND	ND	ND	ND	ND	ND	ND	ND	.016502	ND	ND	ND	ND	ND
PCB 87	ND	ND	ND	ND	ND	ND	ND	ND	.016502	ND	ND	ND	ND	ND
PCB 1254	ND	ND	ND	ND	ND	ND	ND	ND	.08983	.014487	ND	ND	ND	ND
PCB TOTAL	ND	ND	ND	ND	ND	ND	ND	ND	.09901	.014993	ND	ND	ND	ND

ND = not detected